

NPOESS environmental data products for civil and military applications, and climate monitoring

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ABSTRACT

The National Polar-orbiting Operational Environmental Satellite System (NPOESS) will produce 54 environmental data products serving military and civil operational users and the science community, supporting the atmospheric, cloud, land, ocean/water, earth radiation budget, and space remote sensing disciplines. Data products that are key to operations include imagery, atmospheric temperature and moisture profiling, sea surface temperature and wind speed/direction, and soil moisture. NPOESS exploits advanced sensor and data product development on the Earth Observing System (EOS) and other envirosats, including a predecessor mission, the NPOESS Preparatory Project (NPP). The NPOESS data products will be used in weather forecasting, operational decision making, and climate monitoring. The products are delivered with low latency following data acquisition on-orbit by using downlink to a globally distributed network. Synergistic interconnected processing of data products is used to improve quality and reliability. Because the NPOESS system will serve for many years, planning has included consideration of product improvements and long term measurement stability for support to climate monitoring.

Keywords: NPOESS, NPP, DMSP, POES, environmental satellite, data products, operations, weather, climate

1. INTRODUCTION

The NPOESS mission is to provide a national, operational, polar-orbiting remote sensing capability, which converges the missions of the DoD DMSP and the DOC NOAA POES missions, delivering environmental data products for weather forecasting and operational support to both agencies. In addition NPOESS will provide continuity to the NASA science mission for environmental remote sensing and climate monitoring, following the EOS satellites. The NPP launch is scheduled for late 2006, and NPOESS satellites C1 through C5 span 2009 to 2017 launch dates. NPOESS will feature timely on-orbit collection of remotely sensed data, advanced processing for data quality, and delivery of environmental data products to both operational users and the NOAA archive for use in scientific research and climate monitoring.

User needs drive the overall data product requirements for production and delivery. NPOESS will provide a ten fold increase in data, compared to DMSP and POES combined, to support environmental analyses for operations and scientific research. Even though NPOESS is a polar-orbiting system and not a geo-stationary system for near real-time imagery, the data products will be available with a latency following on-orbit data acquisition not to exceed 15 minutes 77% of the time, and less than 28 minutes 95% of the time, supporting forecast warnings and nowcasts. System availability will exceed 94.3%. During operation, data availability for civil and military applications will exceed 99.95%.

NPOESS will deliver 54 data products using advanced sensing of the environment for application to:

- Weather prediction, research in modeling of the weather
- Aviation and maritime operations, space navigation
- Warfighter and peacekeeping activities, disaster relief
- Earth science, climate monitoring and research
- Agriculture support and resource management
- Search and rescue, data collection from in situ platforms such as buoys

The NPOESS program also includes pre-planned product improvement (P3I) for 21 additional data products.

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2. ENVIRONMENTAL DATA PRODUCTS

Table 1 shows the 54 data products, called Environmental Data Records (EDRs), for the NPOESS mission and the sensor(s) providing the primary data for each of the EDRs. Note that there are several EDRs that are denoted as “key”. These are critical to the operational mission and will require the launch of a replacement satellite/sensor, if a failure occurs preventing the EDR from being produced. The EDRs tabulated relate to the atmosphere, clouds, land, ocean/water, earth radiation budget, and space environment. NPP sensors and EDRs are also indicated. NPOESS also provides services for search and rescue (SARSAT) and for collection of data from in situ platforms (ARGOS DCS).

Table 1. Environmental Data Records for NPOESS and NPP. NPP sensors and EDRs are shaded. Sensors used to produce the EDR are indicated:

VIIRS – Visible/Infrared Imager Radiometer Suite
 CrIS - Cross-track Infrared Sounder
 OMPS – Ozone Mapping and Profiler Suite
 ERBS - Earth Radiation Budget Suite
 ALT – Radar Altimeter

CMIS - Conical Scanning Microwave Imager/Sounder
 ATMS - Advanced Technology Microwave Sounder
 SESS – Space Environment Sensor Suite
 TSIS – Total Solar Irradiance Sensor
 APS – Aerosol Polarimetry Sensor

Environmental Data Record	VIIRS	CMIS	CrIS ATMS	OMPS	SESS	ERBS	TSIS	ALT	APS
Key EDRs									
Atmospheric Vertical Moisture Profile		X	X						
Atmospheric Vertical Temperature Profile		X	X						
Imagery	X	X							
Sea Surface Temperature	X	X							
Sea Surface Winds		X							
Soil Moisture	X	X							
Atmospheric EDRs									
Aerosol Optical Thickness	X								X
Aerosol Particle Size	X								X
Suspended Matter	X								
Aerosol Refractive Index, SS Albedo, Shape									X
Ozone Total Column/Profile				X					
Precipitable Water	X	X							
Precipitation Rate/Type		X							
Pressure (Surface/Profile)		X	X						
Total Water Content		X							
Cloud EDRs									
Cloud Base Height	X	X							
Cloud Cover/Layers	X								
Cloud Effective Particle Size	X								
Cloud Ice Water Path		X							
Cloud Liquid Water		X							
Cloud Optical Thickness	X								
Cloud Top Height	X								
Cloud Top Pressure	X								
Cloud Top Temperature	X								
Cloud Particle Size/Distribution									X
Earth Radiation Budget EDRs									
Net Solar Radiation (TOA)						X			
Albedo (Surface)	X								
Down LW Radiance (Surface)						X			
Down SW Radiance (Surface)						X			
Outgoing LW Radiation (TOA)						X			
Solar Irradiance							X		
Land EDRs									
Land Surface Temperature	X	X							
Vegetative Index	X								
Snow Cover/Depth	X	X							
Surface Type	X	X							
Surface Type – Active Fires	X								

Environmental Data Record	VIIRS	CMIS	CrIS ATMS	OMPS	SESS	ERBS	TSIS	ALT	APS
Ocean/Water EDRs									
Ice Surface Temperature	X	X							
Net Heat Flux	X					X			
Ocean Color/Chlorophyll	X								
Ocean Wave Character								X	
Sea Ice Characterization	X	X							
Sea Surface Height/Topography								X	
Surface Wind Stress		X						X	
Space Environment EDRs									
Auroral Boundary					X				
Auroral Energy Deposition					X				
Auroral Imagery					X				
Electric Fields					X				
Electron Density Profile					X				
In situ Plasma Fluctuation					X				
In situ Plasma Temperatures					X				
Neutral Density Profile					X				
Med Energy Charged Particles					X				
Energetic Ions					X				
Supra-Thermal Auroral Properties					X				

The EDRs are processed by algorithms, which start with Raw Data Records (RDRs) and proceed through Sensor Data Records (SDRs):

- RDRs are full resolution, digital sensor data, time-referenced and geolocated in earth coordinates. Absolute spectral, radiometric and geometric calibration coefficients are appended, but not applied, to the data.
- SDRs are produced when algorithms convert RDRs to geo-located calibrated measured fluxes with associated ephemeris data (or orbit-located for in situ space environment measurements). The SDRs are processed to sensor units, such as brightness temperature or radiance. The data necessary to convert the sensor units back to raw data are included.
- EDRs are data records produced when an algorithm converts SDRs to the geophysical parameters that are the object of the measurements. Ancillary data that are used by the algorithms are indicated.

Historically, operational systems have specified orbital and sensor parameters. Reliable algorithms, not necessarily advanced, have been applied to the data to produce the data products. Although operational, the heritage systems DMSP and POES have proven to be workhorses for the research community in the development of understanding of the earth's environment and in improving algorithms used to retrieve environmental parameters.

NPOESS represents a departure from the historical approach in that requirements have been levied on the data products themselves to ensure that user needs are satisfied, with error allocation between sensors and algorithms. Indeed, during the program development period minimum requirements (thresholds) and objectives, along with EDR priority, were specified by the NPOESS program to encourage trades to achieve EDR quality for a reasonable cost. Table 2 shows the basic approach of specifying EDR requirements in terms of attributes related to measurement quality, spatial characteristics, data timeliness, and long term measurement stability. The measurement quality attributes relate directly to remote sensing, e.g. sensor signal-to-noise, optical resolution or algorithm aggregation of optical pixels, and inherent bias residual after calibration or training of a retrieval algorithm. Other attributes relate to system architecture, e.g. timeliness depends on downlink and data routing/retrieval at the data product processing locations, as well as computational and storage horsepower. By using a distributed network of receivers around the globe, instead of the traditional approach of polar ground stations, NPOESS is able to downlink the data to the processing centrals in near real time. For space environment EDRs, there are attributes related to in situ measurements along the orbital path.

Table 2. Standardized Description of NPOESS EDR Requirements in Data Product Attributes

Requirements Basis	Quality Attributes	Related To:
Data products are directly specified by remote sensing attributes	<ul style="list-style-type: none"> Range 	<ul style="list-style-type: none"> signals from measured or interfering phenomenon detection responsivity range, noise floor algorithm range of applicability
	<ul style="list-style-type: none"> Uncertainty (RMS) 	<ul style="list-style-type: none"> sensor signal-to-noise, number of channels used varying environment, applicable conditions algorithm statistics, environment corrections
	<ul style="list-style-type: none"> Accuracy (Bias) 	<ul style="list-style-type: none"> limits on signals-to-phenomenon relationship limitations or skewness in training data set errors in sensor calibration or algorithm tuning
	<ul style="list-style-type: none"> Precision 	<ul style="list-style-type: none"> Uncertainty with bias removed
	Spatial Attributes	Related To:
	<ul style="list-style-type: none"> Horizontal Cell Size Vertical Cell Size 	<ul style="list-style-type: none"> HCS - optical resolution, processing aggregate VCS - number of spectral channels, line widths
Attributes also relate to the spacecraft, as well as orbital, downlink, and processing architecture	<ul style="list-style-type: none"> Mapping Accuracy 	<ul style="list-style-type: none"> spacecraft location, pointing, jitter; geo-location
	Timeliness Attributes	Related To:
	<ul style="list-style-type: none"> Revisit 	<ul style="list-style-type: none"> number of orbital planes, sensor swath width
	<ul style="list-style-type: none"> Refresh 	<ul style="list-style-type: none"> Revisit + max variation in processing time
	<ul style="list-style-type: none"> Latency 	<ul style="list-style-type: none"> time from satellite visit to EDR availability
	Reporting Interval Attributes	Related To:
	<ul style="list-style-type: none"> Horizontal/Vertical 	<ul style="list-style-type: none"> user grids, data use for other EDR processing
	<ul style="list-style-type: none"> In Situ Attributes 	<ul style="list-style-type: none"> select EDRs (space environment) at intervals along orbit track
Stability attribute is important to trend studies over time	Stability Attributes	Related To:
	<ul style="list-style-type: none"> Long Term Stability 	<ul style="list-style-type: none"> long-term drift in detectors or electronics, gradual contamination or deterioration of optics

3. USER COMMUNITY AND DATA PRODUCT APPLICATIONS

NPOESS data product users are many and varied. They include operational users at DoD and DOC weather centrals:

- NOAA National Environmental Satellite, Data, and Information Service (NESDIS), National Center for Environmental Prediction (NCEP)
- Air Force Weather Agency (AFWA)
- Navy Fleet Numerical Meteorology and Oceanography Center (FNMOC)
- Naval Oceanographic Office (NAVOCEANO).

These are the centers to which NPOESS RDRs are routed following downlink from orbit to the globally distributed network of receivers. SDRs and EDRs are processed at these centers prior to delivery to the NOAA CLASS archive for retention. Other U.S. users include the NOAA National Weather Service (NWS), NOAA Regional Forecast Centers, NOAA Marine Prediction Center, National Climate Data Center (NCDC), and the NOAA Hydrometeorological Prediction Center. There are also field terminals in the hundreds operated by the DoD, DOC, and private concerns around the world. Some of these terminals, denoted HRD for high rate data, provide data products and processing on a par with the Centrals, while other terminals, denoted LRD for low rate data, are truly portable systems that receive direct readout from the orbiting NPOESS satellite. The primary European user is the European Centre for Medium Range Weather Forecasts (ECMWF). International services include Search and Rescue Satellite-Aided Tracking (SARSAT) and the Data Collection System (ARGOS), mentioned above. Finally there are commercial information providers, private forecasters and university researchers that use NPOESS environmental data for varied applications.

Table 3. provides a summary of civil and military applications versus key EDRs and classes of EDR products. Weather forecasting and nowcasting are important for both civil and military operations, as well as planning. The use of data products for decision aids, whether it be to support a military decision or routing of ships, is as important as the more complex use of NPOESS data in numerical weather prediction and in scientific models.

Table 3. Summary of civil and military applications of NPOESS data products

NPOESS Key EDRs (*) or EDR Product Type	Civil Application	Military Application
Atmospheric Profiles: Temperature*, Humidity*	Improved weather forecasting	More reliable forecasts for mission planning
Cloud Imagery*, Cloud Products, Precipitation Products	Nowcasts, weather events	Aircraft operations, tactical planning, target visibility
Ocean Wind Vectors*, Sea Height/Wave Parameters	Shipping safety, port/beach operations, site selection	Aircraft carrier and amphibious operations
Sea Surface Temperature*, Sea Height/Wave Parameters, Ocean Color	Fisheries, pollution tracking, El Nino/La Nina forecasts	Mine clearing, anti-submarine warfare, special operations
Soil Moisture*, Land/Vegetation Products	Agriculture, water and land use management	Mobility, trafficability, cover assessment
Aerosols, Dust, and Ash Products	Aviation hazards, atmospheric research	Aviation hazards, target visibility
Ozone Column and Profile Products	Ozone monitoring, depletion, mechanisms	
Energy Balance, Radiation Products	Improved weather forecast, climate change models	Improved weather forecast
Climate Relevant Products	Long term climate monitoring, climate change, prediction	
Space Environment Products	Research, power grid and communications disruption	Space weather, EMI, sensor damage

Although NPOESS will achieve a convergence of the DoD and DOC NOAA operational missions, NPOESS and its preparatory mission NPP are also important to the continuity of the NASA science mission for earth remote sensing and climate monitoring and research. Climatologists study energy balance, radiation and temperature, atmospheric constituency, hydrology cycles and water distribution. Trends and cycles are tracked globally and regionally, annually and seasonally. This trending is used to monitor and extrapolate true environmental changes. Adequate calibration is essential; trends must be differentiated from systematic effects on measurements or deficiencies in algorithms retrieving environmental parameters. These trends and cycles are also used in understanding climate dynamics supporting model development.

4. NASA SCIENCE MISSION, CLIMATE MONITORING AND RESEARCH

Long term measurement stability requirements have been imposed on sensors and 30 of the EDRs to support the NASA science mission and climate studies. These are shown in Table 4. The climatology uses include monitoring as well as study and model development. Measurement of variations and trends in the climate system, study of important forcing parameters in the overall system, study of response to forcings and the feedback processes, and model prediction and assessment through comparison with data are important. Additional NPOESS products that are of interest to climatology, but do not have stability requirements, are also shown in Table 4. Cal/Val, data processing and storage infrastructure, and long term monitoring will assure stability of the data products. All RDRs, SDRs, EDRs are provided to the NASA CLASS archive to enable trend studies related to climate change and enable reprocessing of the data, as data product retrieval algorithms mature scientifically through research and improved understanding of the environment and climate. NPP Science Teams have been formed to examine NPOESS SDRs/EDRs to understand and better develop application to the climate mission. SDR integrity is most important, since EDR algorithm improvements are continually being researched. Algorithms can be improved in time, but the historical record important to climate studies cannot be, if the data acquisition from orbit does not provide for adequate SDRs.

Table 4. EDRs, most with long term stability (LTS) requirements, supporting climate monitoring and research. Applicability to climate studies is also indicated, for which systematic continual measurements are necessary.¹

V – Climate system variations and trends F - Primary forcings on climate system
R - Response and feedback process studies P – Model prediction and assessment

EDR (Key *) with LTS Requirement	Climatology Application	EDR (Key *) with LTS Requirement	Climatology Application
Atmospheric Vertical Moisture Profile *	V, R	Cloud Top Pressure	R
Atmospheric Vertical Temperature Profile *	V, R	Cloud Top Temperature	R
Sea Surface Temperature *	V, P	Down LW Radiance (Surface)	R
Sea Surface Winds *	V, R, P	Down SW Radiance (Surface)	R
Aerosol Optical Thickness	F	Net Solar Radiation (Top of Atmosphere)	R
Aerosol Particle Size	F	Ocean Color/Chlorophyll	V, R
Aerosol Refr. Index, Single Scattering Albedo, Shape	F	Outgoing LW Radiation (Top of Atmosphere)	R
Albedo (Surface)	R	Ozone Total Column/Profile	V, R, P
Cloud Base Height	R	Precipitable Water	V, R, P
Cloud Effective Particle Size	R	Precipitation Rate/Type	V, R, P
Cloud Ice Water Path	R	Sea Ice Characterization	V, R
Cloud Liquid Water	R	Sea Surface Height/Topography	V, P
Cloud Optical Thickness	R	Snow Cover/Depth	R
Cloud Particle Size/Distribution	R	Solar Irradiance	F
Cloud Top Height	R	Vegetative Index	V, F, R, P
EDR (Key *) without LTS Requirement	Climatology Application	EDR (Key *) without LTS Requirement	Climatology Application
Soil Moisture*	V, R, P	Surface Type: Active Fires	F
Surface Type	V, F, P, R		

5. ADVANCED PROCESSING OF ENVIRONMENTAL DATA PRODUCTS

EDR processing involves remotely sensed data, spacecraft and environmental background data, intermediate products, and retrieval algorithms. Figure 1 is a generalized schematic of a single EDR's processing showing the interconnectivity and flow of the processing of a single EDR product. Algorithms relating spectral signatures of phenomenon measured to the value retrieved for the EDR include:

- empirical relationships, for which coefficients may be optimized for region/season or humidity/temperature conditions; empirical corrections for interfering or screening phenomena are often included
- physical models, which may be computationally intensive, requiring pre-computation and compilation in lookup tables (LUTs); iteration from an initial guess to a converged solution may be involved, if the measured data are not completely determinate of the value to be retrieved

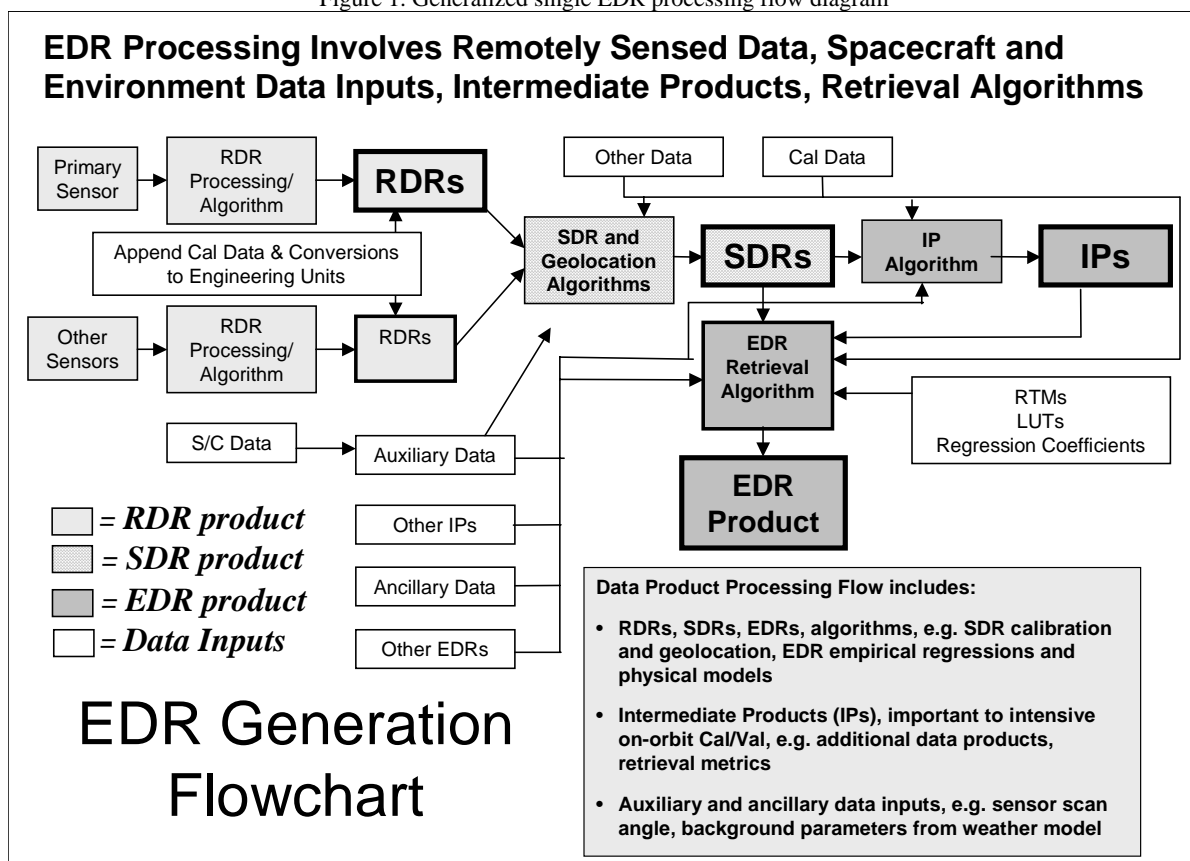
The NPOESS algorithms build on advances to heritage approaches, being tested on the Earth Observing System (EOS) satellites Aqua and Terra currently in orbit and the DMSP Block 5D3 satellites being launched. The EOS MODIS, AMSR, AIRS/AMSU, CERES sensors and algorithms are predecessors to NPOESS VIIRS, CMIS, CrIS/ATMS (CrIMSS), and ERBS respectively. The DMPS SSM/IS is a predecessor to NPOESS CMIS, and DMSP SSULI/SSUSI

to NPOESS SESS ultraviolet sensors. OMPS builds on SBUV and TOMS. In addition, other envirosats will prepare the way for NPOESS through risk reduction, e.g. WindSat is testing Sea Surface Wind data products, TRMM has tested precipitation measurements, CloudSat supports cloud studies. Ultimately, NPP will shakedown NPOESS sensors and algorithms for data products directly with VIIRS, CrIS/ATMS, and OMPS.

Intermediate products (IPs) in EDR processing have physical significance, i.e. they are not simply transient numerical data arrays, and include such things as Cloud Mask, Surface Reflectance, Surface and Cloud Emissivities, Uncertainties and Noise Equivalent Radiances. There are many such products for NPOESS that will be used in intensive on-orbit step-by-step validation of the EDRs.

Auxiliary data consists of basic data from the spacecraft and sensors, such as sensor scan angle, solar zenith angle. Ancillary data includes information on environmental background of an EDR measurement from recent Numerical Weather Predictions (e.g. NCEP GFS or FNMOC NOGAPS models), Climate Statistical Databases, digital elevation maps, snow cover maps, etc. There are numerous such data sets identified for NPOESS data product processing.

Figure 1. Generalized single EDR processing flow diagram



For NPOESS, EDRs are not processed in a stand-alone mode. NPOESS sensors span a broad spectral range in remotely sensed phenomena. Interconnected processing between EDRs improves data product quality, availability, and monitoring. Cross-sensor synergisms are exploited via:

- Use of complementary sensors, e.g. VIIRS and CMIS, for clear and cloudy measurements to produce the EDR
- Use of EDRs as input to EDR processing, as the best available information on background environmental conditions

- “Data fusion”, e.g. CrIS/ATMS tandem use for atmospheric sounding of humidity and temperature, building on the development and testing of AIRS/AMSU for EOS Aqua satellite currently in orbit
- Potential fallback EDRs in case of on-orbit anomalies, such as sensor or sensor channel failure, or sensor channel degradation, e.g. use of CrIS to produce select cloud products in absence of VIIRS data, use of ATMS to produce precipitation products in absence of CMIS data.

Alternative inputs to an EDR’s processing for background environmental conditions are used in a prioritized scheme, providing best available inputs and also graceful degradation:

- Other EDRs (highest priority, best information)
- Numerical Weather Prediction (mid-priority, good information)
- Climate Statistics (lowest priority, average information)

Although EDR quality is reduced using Climate Statistics, there is an advantage for portable field terminals, which do not have convenient access to the processing facilities at the NOAA, Air Force, and Navy Centrals. Using Climate Statistics EDRs can be processed with significantly reduced dependency on other EDRs and dynamic ancillary data. However, some dynamic products, such as the Cloud Mask identifying clear and cloudy areas, would still be required.

Quality flags are generated at various points in EDR processing and indicate performance degradation or exclusion from:

- Basic performance constraints, e.g. solar zenith angle, scan angle
- Interfering phenomenon, e.g. precipitation, clouds, aerosols

Quality flags will also provide system operators with indications of anomalies, and analysts with information on processing branching within algorithms, important to algorithm tuning and development.

RDRs, SDRs, and EDRs and select IPs are provided to NOAA for long term archiving. Metadata identifying algorithm version, ancillary data used, quality flags, etc., are delivered with every EDR and will enable reprocessing by algorithm developers and climate researchers.

6. PRE-PLANNED DATA PRODUCT IMPROVEMENTS

The NPOESS program has included pre-planned product improvements (P3I), since it will serve as the nation’s polar operational environmental satellite system for decades and must allow for improvements in technology, sensors, and data product algorithms. Figure 2 shows some 21 potential EDRs, which were identified in addition to the 54 NPOESS EDRs as having high value to the operational and science communities. Note that the tropospheric winds (profile) product is the highest priority, as this is anticipated to have the greatest impact on weather prediction, just as atmospheric sounding was the World Meteorological Organization’s goal of the previous decade for operational realization, to occur on NPOESS. Trace gas measurements are also listed because of their importance to understanding of the atmosphere. Finally, there are a large number of data products that may be recognized as NPOESS EDRs applied to coastal regions, because of obvious interest by the military in shallow water operations and by the civil community to fisheries, beach management, navigation, and understanding of coastal processes. Current realization of the ambitious goals of these P3I EDRs would involve sensors impractical for NPOESS accommodation, because of weight, power, volume consideration, e.g. lidar, or because of immature technology. Similarly, the algorithms may currently be developmental and require further years of research before operational implementation can be attempted. That being said, the existing NPOESS sensors have substantial capability to support that research and to provide P3I data products with significant value, though less than the ideal performance that is ultimately desired. The program is currently evaluating inclusion of a modification to VIIRS on later NPOESS flights that would permit imagery of water vapor clouds with a 6.7 micron channel. Time-differenced imagery of both visible and water vapor clouds over the poles, where the three NPOESS satellites would provide rapid refresh, e.g. 20 minutes or so, would enable retrieval of tropospheric wind profiles for use by forecast models with significant impact on forecast accuracy. For climatology, the tropospheric winds data product is also important for prediction and assessment studies. Trace gases are important for study of forcings, response and feedback, and prediction and assessment. Coastal ocean parameters are important for response and feedback studies.

Figure 2. Pre-Planned Product Improvements for NPOESS involve 21 additional data products of importance to the user community.

P3I EDR		Algorithm Status	Sensor Status
70.1.1	Tropospheric Winds Profile	P	N Lidar
70.1.2	CH4 Column	P	E CrIS
70.1.3	CO Column	P	E CrIS
70.1.4	CO2 Column	P	E CrIS
70.1.5	Optical Background	L	M CrIS
70.1.6	All Weather Day/Night Imagery	L	N SAR
70.1.7	Sea and Lake Ice	P	E VIIRS/ALT
70.1.8	Littoral Currents	P	M ALT
70.1.9	Coastal Ocean Color	P	E VIIRS
70.1.10	Bioluminescence Potential	P	E VIIRS
70.1.11	Coastal Sea Surface Temperature (SST)	P	E VIIRS

P3I EDR		Algorithm Status	Sensor Status
70.1.12	Coastal Sea Surface Winds	X	N SAR
70.1.13	Sea Surface Height Coastal	P	M ALT
70.1.14	Coastal Imagery	P	E VIIRS
70.1.15	Ocean Wave Characteristics	P	M ALT
70.1.16	Surf Conditions	X	N SAR/Model
70.1.17	Bathymetry (Deep Ocean & Near-shore)	P	M ALT
70.1.18	Salinity	P	N SMOS-class
70.1.19	Oil Spill Location	P	N SAR/VIIRS
70.1.20	Vertical Hydrometeor Profile	L	N TRMM PR
70.1.21	Neutral Wind	L	N TIDI/HRDI

Legacy Algorithm	L	E	NPOESS Sensor
Prototype	P	M	Modify NPOESS
New Approach	X	N	New Sensor

Roadmap to satisfy evolving user needs as the program matures;

Existing or **Modified** NPOESS sensors provide substantial capability for data products from future algorithms

7. SUMMARY

In summary, NPOESS will provide high quality data products in many environmental categories supporting civil and military operations, weather forecast, and climate monitoring and research. The categories include atmosphere, clouds, land, sea, earth radiation, and space environment. A subset of the EDRs are critical to civil and military operations, while many of the EDRs are important to climate monitoring, and have associated long term measurement stability requirements. The data products will be delivered within 15 minutes of on-orbit data acquisition 77% of the time, and no later than 28 minutes 95% of the time to support forecast warnings and nowcasts. Very high system and data availability are to be provided, as well as data archiving by NOAA of the data products for climate studies, research support, and development of improved data product algorithms. Finally, NPOESS includes pre-planned product improvements, since it will serve for many decades.

8. REFERENCES

1. DOC NOAA NESDIS, The United States Detailed National Climate Report on Systematic Observations for Climate, August 2001